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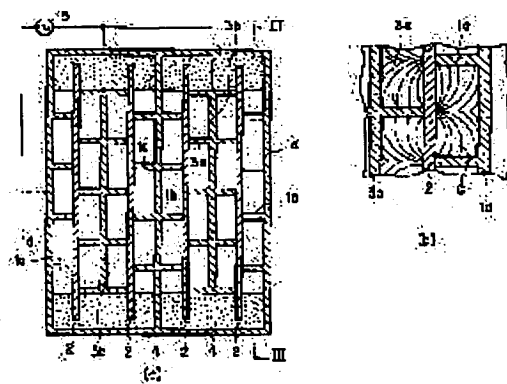
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## (54) ELECTRIC FIELD APPARATUS FOR GAS OXIDATION

### (57)Abstract:

**PURPOSE:** To provide an electric field apparatus for gas oxidation which can generate a uniform plasma regardless of properties of a gas to be treated.

**CONSTITUTION:** By arranging projections 1a and 3a and 1c and 3a of electrodes with the same shape in such a way that they are shifted and not neighbor with each other e.g. on the right side and the left side of a dielectric 2, creeping discharge is generated on the face of the opposite side to the face where the dielectric 2 is brought into contact with the projections 1a, 1c and 3a, namely, the surface of the dielectric with which the electrode is not brought into contact. At the same time, as electrodes 1a, 1d, 1b, 1c, 3a and 3b are arranged to the creeping discharge generating face and an electric voltage being the same polarity as that of the creeping discharge generating face is applied, a space between the creeping discharge generating face and the electrodes arranged so as to surround it, namely, the inside of a cylindrical gas flow path is turned to a glow discharge plasma condition.



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**CLAIMS**

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**[Claim(s)]**

[Claim 1] The 1st electrode which has two or more steps of ledged projections up and down toward the interior from the right-and-left side attachment wall of an rectangular pipe-like outer frame, The 1st ctenidium-like electrode which has the ledged projection of the 1st electrode of the above, and two or more steps of ledged projections corresponding to right-and-left both sides from the septum with which the interior of the above-mentioned outer frame is divided into right-and-left plurality, The 2nd ctenidium-like electrode which is in the location which shifted from the ledged projection of the 1st electrode of the above, and each 1st ctenidium-like electrode to the right-and-left both sides of a flat wall alternately, and has two or more steps of ledged projections, It has the dielectric which contacts each ledged projection with the 1st electrode of the above, and a 2nd ctenidium-like electrode, is located between them, and contacts each ledged projection with the above-mentioned 1st ctenidium-like electrode and a 2nd ctenidium-like electrode, and is located between them. Electric-field equipment for gas oxidation which impressed a different polar electrical potential difference between the 1st electrode of the above and a 1st ctenidium-like electrode, and a 2nd ctenidium-like electrode.

[Claim 2] The 1st electrode which has two or more radial projections toward an internal core from the inner circle wall of a cylinder-like outer frame, The cylinder-like 1st dielectric with which a peripheral wall contacts the interior of the tip of a radial projection of this 1st electrode, While it is inside this 1st dielectric, and it is cylindrical and taking equally the radii distance during the radial projection to which it has a radial projection in both a peripheral wall and an inner circle wall, and a peripheral-wall side adjoins them One step or two or more steps of 2nd electrode with which the radii distance during the radial projection with which the radial projection by the side of the above-mentioned peripheral wall and the radial projection of the electrode of the outside are made into the physical relationship alternately shifted, and which an inner circle wall side adjoins is equally taken, and the radial projection tip of the above-mentioned peripheral wall contacts the inner circle wall of a cylindrical dielectric further, The cylinder-like 2nd dielectric with which a peripheral wall contacts the radial projection of the inner circle wall of this 2nd electrode, The tip of a radial projection contacts the inner circle wall of the 2nd dielectric of the above, and it has the 3rd electrode which keeps the radii distance of the radial projection which puts together all the end faces of this radial projection, and adjoins each other from the physical relationship which moreover shifted alternately this radial projection and the radial projection of the inner circle wall of the 2nd electrode of the above equally. The electrode for gas oxidation it was made to impress a different polarity to the electrode which adjoins each other on both sides of the above-mentioned dielectric.

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**DETAILED DESCRIPTION**

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[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention is O<sub>2</sub>. It oxidizes and is O<sub>3</sub>. The equipment which manufactures and makes deodorization and a combustion efficiency improvement, or NO<sub>x</sub> SO<sub>x</sub> It is related with the electric-field equipment for gas oxidation applied to the offgas treatment equipment which oxidizes and performs denitrification and desulfurization.

[0002]

[Description of the Prior Art] Drawing 7 and drawing 8 are the explanatory views of the electric-field equipment for gas oxidation used from the former. It is NO<sub>x</sub> in the exhaust gas of for example, a gas \*\*\*\* boiler by this equipment. It explains taking the case of the case where it processes. In drawing 7, 101 is the reaction container of the conventional electric-field equipment for gas oxidation, and the path which has a square cross section adjoins a flight, and is arranged, and it forms the honeycomb structure object which consists of insulating ceramics, such as alumina ceramics, silicon nitride porcelain, and zirconia ceramics. If one tubular path of this honeycomb structure object is explained, this is constituted by four continuous walls of 102,103,104,105, and if it develops, it will become like drawing 8. Moreover, a wall 102,103,104,105 makes the structure bent by 90 degrees according to the boundary line 106,107,108,109. The corona discharge pole 113,114 which follows the end 110 of a wall 102 with the terminal 111,112 which stands in a row to a power source 127, and consists of electric conduction film, such as a tungsten, is mutually continued and installed in the front face of a wall 102,103,104,105 regular intervals and in parallel.

[0003] If the pulse height electrical potential difference whose pulse width is 1ns - about 1000ns is impressed among the above-mentioned corona discharge poles 113 and 114, introducing the exhaust gas of a gas \*\*\*\* boiler into the interior of the reaction container 101 of such a configuration, pulse corona discharge will be generated near [ the ] the wall front face, and exhaust gas will be plasma-ized. If it does so, the following chemical reaction will occur in the plasma-ized exhaust gas.

$2O_2 \rightarrow O_3 + 1 / 2O_2$  NO+O<sub>3</sub>  $\rightarrow$  The NO<sub>2</sub>+O<sub>2</sub> above-mentioned reaction formula is O<sub>2</sub> contained in exhaust gas. A molecule is O<sub>3</sub> by the plasma. It becomes and is O<sub>3</sub> further. NO which is an injurious ingredient is oxidized and it is NO<sub>2</sub>. Carrying out is shown. NO<sub>2</sub> generated here By adsorbing with the reduction and the adsorbent by alkali cleaning, easily, it is removable or can defanging process. Therefore, NO<sub>x</sub> in the exhaust gas which do not require a big location but be discharge as large electric field equipment for gas oxidation of capacity from the equipment accompanied by the combustion efficiency improvement of the various equipments accompanied by [ it be small and ] deodorization or combustion, or various combustion even if it become three-dimensional structure, since the corona discharge pole 113,114 can be establish in the tubular path wall 102,103,104,105 SO<sub>x</sub> It be apply to the offgas treatment equipment to remove.

[0004]

[Problem(s) to be Solved by the Invention] However, with conventional equipment, there were the following faults and there was a trouble that utilization was very difficult.

(1) Since it is the structure where only space exists between electrodes, when waterdrop is in the case where there is much moisture in gas, or the tubular path wall 102,103,104,105, for example, inter-electrode insulating strength falls extremely, arc discharge occurs, the plasma becomes uneven, and it may be able to stop being able to process. Therefore, it is easy to be influenced of the descriptions (moisture, oil, etc.) of processed gas.

(2) Although conductive film, such as a tungsten, is used for the tubular path wall 102,103,104,105 of a honeycomb structure object as a discharge electrode, costs, such as the membrane formation, electric supply, etc., are very high.

(3) Although the ceramics of a honeycomb structure object is used as a dielectric, a maintenance on the structure is difficult, and since they must all be exchanged if some honeycomb structure objects should be damaged, a maintenance cost is very high.

[0005] This invention aims at offer of the electric-field equipment for gas oxidation which generates the plasma of the homogeneity which have to carry out no exchange even if some dielectrics are damaged without putting Rhine used as the conventional \*\*\*\*\* in view of an above-mentioned problem.

[0006]

[Means for Solving the Problem] The 1st electrode with which the configuration of this invention which attains the above-mentioned purpose has two or more steps of ledged projections up and down toward the interior from the right-and-left side attachment wall of a (1) rectangular-pipe-like outer frame, The 1st ctenidium-like electrode which has the ledged projection of the 1st electrode of the above, and two or more steps of ledged projections corresponding to right-and-left both sides from the septum with which the interior of the above-mentioned outer frame is divided into right-and-left plurality, The 2nd ctenidium-like electrode which is in the location which shifted from the ledged projection of the 1st electrode of the above, and each 1st ctenidium-like electrode to the right-and-left both sides of a flat wall alternately, and has two or more steps of ledged projections, It has the dielectric which contacts each ledged projection with the 1st electrode of the above, and a 2nd ctenidium-like electrode, is located between them, and contacts each ledged projection with the above-mentioned 1st ctenidium-like electrode and a 2nd ctenidium-like electrode, and is located between them. The 1st electrode which is characterized by impressing a different polar electrical potential difference between the 1st electrode of the above and a 1st ctenidium-like electrode, and a 2nd ctenidium-like electrode, and has two or more radial projections toward an internal core from the inner circle wall of a (2) cylinder-like outer frame, The cylinder-like 1st dielectric with which a peripheral wall contacts the interior of the tip of a radial projection of this 1st electrode, While it is inside this 1st dielectric, and it is cylindrical and taking equally the radii distance during the radial projection to which it has a radial projection in both a peripheral wall and an inner circle wall, and a peripheral-wall side adjoins them One step or two or more steps of 2nd electrode with which the radii distance during the radial projection with which the radial projection by the side of the above-mentioned peripheral wall and the radial projection of the electrode of the outside are made into the physical relationship alternately shifted, and which an inner circle wall side adjoins is equally taken, and the radial projection tip of the above-mentioned peripheral wall contacts the inner circle wall of a cylindrical dielectric further, The cylinder-like 2nd dielectric with which a peripheral wall contacts the radial projection of the inner circle wall of this 2nd electrode, The tip of a radial projection contacts the inner circle wall of the 2nd dielectric of the above, and it has the 3rd electrode which keeps the radii distance of the radial projection which puts together all the end faces of this radial projection, and adjoins each other from the physical relationship which moreover shifted alternately this radial projection and the radial projection of the inner circle wall of the 2nd electrode of the above equally. It is characterized by making it impress a different polarity to the electrode which adjoins each other on both sides of the above-mentioned dielectric.

[0007]

[Function] Since it has a projection and a wall and the electrical potential difference of a creeping-discharge generating side and like-pole nature is impressed so that this creeping-discharge generating side may be surrounded while creeping discharge is generated at that rear-face side on the front face of a dielectric where a projection contacts, since the front flesh side of a dielectric is equipped with the ledged projection and radial projection which carried out the location gap, the interior of a gas passageway will be in the glow discharge plasma state. That is, in order to generate a polar electrical potential difference which is different on both sides of a dielectric and to make the glow discharge plasma induce by the creeping discharge on the front face of a dielectric, breakdown voltage is governed by the thickness and inter-electrode distance of a dielectric, and inter-electrode cannot be easily influenced of the description of processed gas, and removal of a dielectric becomes easy, and maintenance is easy. And not the film but manufacture is easy for an electrode, and its cost is sharply low.

[0008]

[Example] Here, the example of this invention is explained with reference to drawing 1 - drawing 3. Drawing 1 is [ the front view of electrode structure and drawing 3 of the external view of the electric-field equipment of the 1st example and drawing 2 ] the sectional side elevations of electrode structure. Two or more ledged projection 1a of a stage is prepared in 1d of right-and-left both-sides walls of the outer frame 1 which is an rectangular pipe-like object up and down over the interior. Furthermore, it has septum 1b in the right-and-left center section by the outer frame 1 and one, and two or more steps ledged projection 1c

corresponding to the right-and-left both sides of this septum 1b is prepared with ledged projection of 1d of above-mentioned side attachment walls 1a. And this outer frame 1 and ledged projection 1a constitute the 1st electrode, and septum 1b and ledged projection 1c constitute a 1st ctenidium-like electrode, for example, it is formed with conductors, such as aluminum and stainless steel. On the other hand, between the 1st electrode and a 1st ctenidium-like electrode, it has a 2nd ctenidium-like electrode. This 2nd ctenidium-like electrode consists of ledged projection 3a formed in 1d of side attachment walls, septum 1b, parallel flat wall 3b, and this flat wall 3b of an outer frame 1 two or more steps up and down, and this ledged projection 3a is formed so that it may become the vertical location of the ledged projections 1d and 1c, and the location shifted. and it arranges so that the ledged projections 1d and 3a of the both sides of the 1st electrode and a 2nd ctenidium-like electrode may be resembled, respectively and may be contacted, for example, so that the dielectric 2 which consists of insulating materials, such as glass and ceramics, may serve as a partition -- having -- moreover, the ledged projections 1c and 3a of the both sides of a 1st ctenidium-like electrode and a 2nd ctenidium-like electrode -- the same dielectric 2 is arranged so that it may contact, respectively. It is the vertical inside of an outer frame 1, and the insulator 4 which is the spacer which fixes a 2nd ctenidium-like electrode up and down, and fixes a dielectric 2 up and down is arranged, for example, it consists of insulating materials, such as ceramics and glass. A power source 5 is a 10Hz - dozens of kHz frequency number. Alternation electrical potential differences, such as a sine wave with an electrical potential difference of several kV - dozens of kV and a pulse wave, are impressed between the 1st electrode, a 1st ctenidium-like electrode, and a 2nd ctenidium-like electrode, and supply the power for plasma generating. [0009] Now, if the power for plasma generating is supplied from a power source 5 between the 1st electrode, a 1st ctenidium-like electrode, and a 2nd ctenidium-like electrode, introducing the exhaust gas of for example, a gas \*\*\*\* boiler into the interior of the 1st electrode and a 1st ctenidium-like electrode, inside the space between those electrodes and dielectrics 2, i.e., a tubular path, glow discharge plasma G like a striped pattern shown in drawing 2 (b) will occur. Discharge is induction \*\*\*\* to the whole gas of the space in the tubular path which this plasma starts discharge near the contact surface of the tip of the ledged projections 1a, 1c, and 3a of the 1st electrode, a 1st ctenidium-like electrode, and a 2nd ctenidium-like electrode, and a dielectric 2, and uses these electrodes and a dielectric 2 as a wall.

[0010] therefore, the plasma state with the gas almost uniform [ the interior ] by which internal installation of the 1st electrode and the 1st ctenidium-like electrode was carried out -- becoming -- NOx in exhaust gas, N<sub>2</sub>, and O<sub>2</sub> etc. -- it is made to excite and dissociate a gas molecule, and it will be in an activity condition chemically. Consequently, the reaction described below is triggered.

$2O_2 \rightarrow O_3 + 1/2 O_2$   $NO + O_3 \rightarrow$  The reaction formula of the NO<sub>2</sub>+O<sub>2</sub> above is NOx introduced into the 1st electrode and a 1st ctenidium-like electrode. NO which is a principal component is NO<sub>2</sub>. Being oxidized is shown. usually, the thing set as the object of emission-gas-purification processing when performing offgas treatment of a gas \*\*\*\* boiler -- NOx it is -- although -- the principal component is NO. NO is NO<sub>2</sub> as mentioned above, although the processing is deficiently difficult for reactivity. If it oxidizes, defanging processing can be easily carried out by the approach of carrying out an adsorbent with the reduction and the adsorbent by alkali cleaning etc. Moreover, since it is shifted and arranged so that a dielectric may be installed in inter-electrode [ from which a polarity differs ] and the electrode of a different polarity may not adjoin each other on both sides of a dielectric, discharge starting is carried out from a dielectric front face, and there is also little electric-field concentration inside a dielectric. Therefore, since it always insulates with the dielectric between discharge electrodes, if influenced of the moisture in gas, oil, etc., the plasma state stabilized that there is nothing is maintainable. Furthermore, four fields of a tubular path wall have the operation to which the third page of a dielectric and \*\* has structure surrounded with the conductor of this potential, carries out flattening of the field strength distribution, and one field makes the plasma homogeneity. Moreover, since throughput can be increased by connecting much electric-field equipments of this example to juxtaposition, or extending a ledged projection and a dielectric to a lengthwise direction, and increasing the number of tubular paths, large-capacity-izing is also easy. And the format which fits a dielectric over the interior of a metal ctenidium-like electrode is easy structure, the maintenance of a dielectric is easy for electrode structure, and it is low. [ of a manufacturing cost ]

[0011] Drawing 4, drawing 5, and drawing 6 explain the 2nd example concerning this invention. Drawing 4 is drawing showing the electric-field equipment of the 2nd example. Drawing in which drawing 5 shows an opening cross section with the front view of electrode structure, and drawing 6 show the side cross section of electrode structure. The 1st electrode has the structure where two or more radial projection 11a projects by hoop direction regular intervals inside cylinder-like outer wall 11b. The 1st dielectric 21 is also nothing and a septum about the shape of a cylinder, and the tip of radial projection 11a of the 1st electrode

touches the outside. In the outside of cylinder-like septum 12b, radial projection 12a has projected two or more 2nd electrode by hoop direction regular intervals, and radial projection 12c has projected it by hoop direction regular intervals also inside septum 12b. [ two or more ] Two or more of these radial projection 12c touches the outside of the 2nd dielectric 22 of that inside. In addition, in radial projection 12c projected to radial projection 12a projected on the outside of septum 12b, and its inside, as for the distance from each adjacent projection, for example, a certain projection 12a, to the next projection 12a, the radii distance from those tips to a tip is equal. Therefore, the number of projection 12c has become less than the number of projection 12a in the outside and the inside of septum 12b. The 2nd dielectric 22 is also nothing and a septum about the shape of a cylinder, two or more radial projection 12c of the 2nd electrode touches the outside, and two or more projection 13a of the 3rd electrode touches inside a septum on it. The 3rd electrode joins two or more radial projection 13a at one edge, the other end, i.e., a tip, touches inside the 2nd dielectric 22, and spacing at the tips of those projection 13a is arranged so that those radii distance may become equal. Moreover, it shifts and the projection (for example, 11a, and 12a, 12c and 13a) which sandwiches the 1st dielectric 21 and 2nd dielectric 22 is arranged by carrying out so that each may not adjoin each other. Furthermore, the radii distance at adjacent monotonous tips is almost fixed, and the wire extension of each radial projection of arrangement of each radial projection is also fixed. In this way, many flabellate form opening cross sections are formed like drawing 5 . In addition, the 1st, 2nd, and 3rd electrodes are formed with metallic materials (conductor), such as aluminum and stainless steel, and the 1st and 2nd dielectrics (21 and 22) are formed by insulating materials, such as glass and ceramics. 5 is a power source, the 1st electrode and 3rd electrode are connected to the terminal of one of these, and the 2nd electrode is connected to the other-end child.

[0012] If power is supplied to the above-mentioned electrode from a power source 5, introducing the exhaust gas of for example, a gas \*\*\*\* boiler into the interior of the electrode of the shape of this cylinder, the glow discharge plasma will occur inside the tubular path which carried out the flabellate form cross section, and the reaction described below as a result will be triggered.

$2O_2 \rightarrow O_3 + 1 / 2O_2$   $NO + O_3 \rightarrow$  The reaction formula of the  $NO_2 + O_2$  above is  $NO_x$  introduced into the 1st electrode.  $NO$  which is a principal component is  $NO_2$ . Being oxidized is shown. In addition, although the 2nd example replaces the plate-like dielectric of said 1st example in the shape of a cylinder, the 1st and 2nd examples are common, and the principle of plasma generating is  $NO_x$ . The engine performance of oxidation treatment is equivalent. At this example, it is  $NO_x$ . It is  $O_3$  although oxidation treatment was explained.  $CO_2$  of generation or  $CO$  It is applicable to oxidation treatment etc. In addition, the 1st and 2nd example can be further formed in multistage.

[0013]

[Effect of the Invention] As explained above, according to this invention, gaseous oxidation-treatment equipment is realizable by the compact and low cost. And since a maintenance is easy and large-capacity-izing is also easy the maintenance, it is  $O_2$ . It oxidizes and is  $O_3$ . The value on industry is remarkably high as electric-field equipments for gas oxidation, such as equipment which oxidizes equipment and  $NO_x$  which manufacture and make deodorization and a combustion efficiency improvement,  $SO_x$ ,  $CO$ , etc., and performs offgas treatment, such as denitrification and desulfurization.

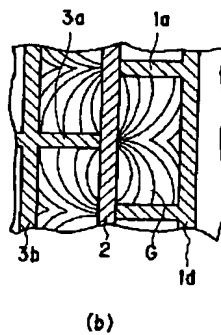
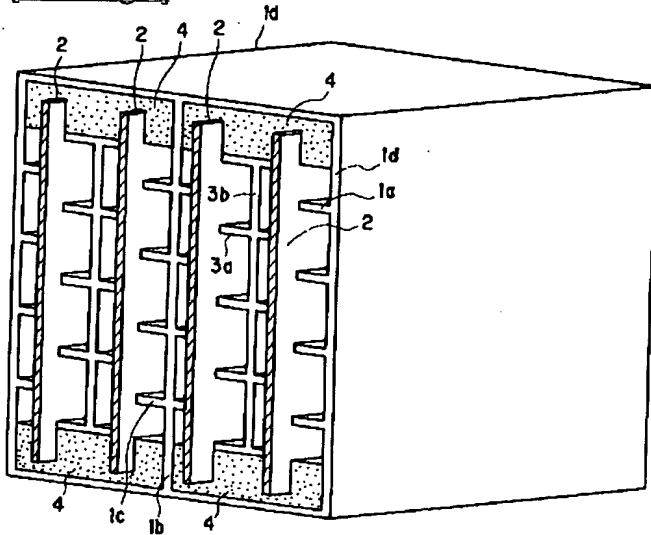
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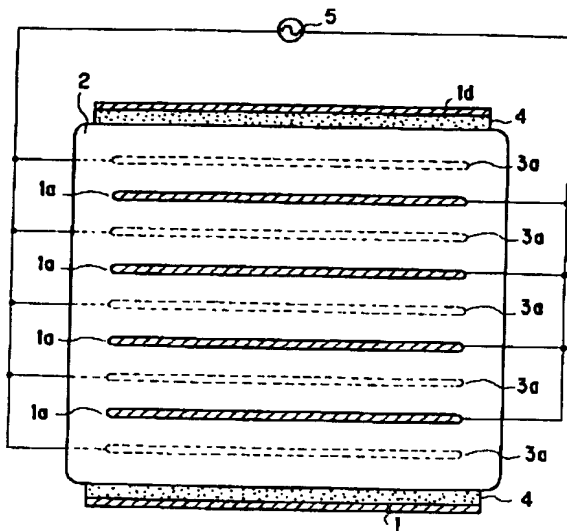
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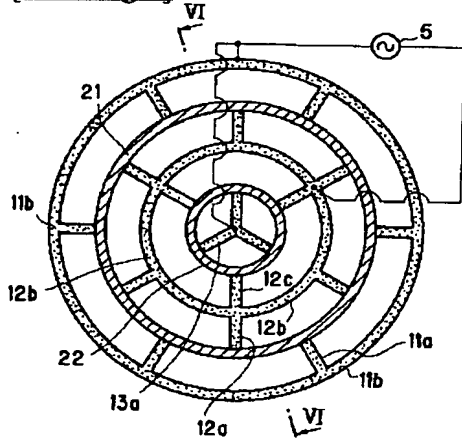
[Drawing 1]



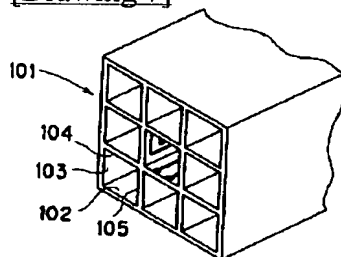
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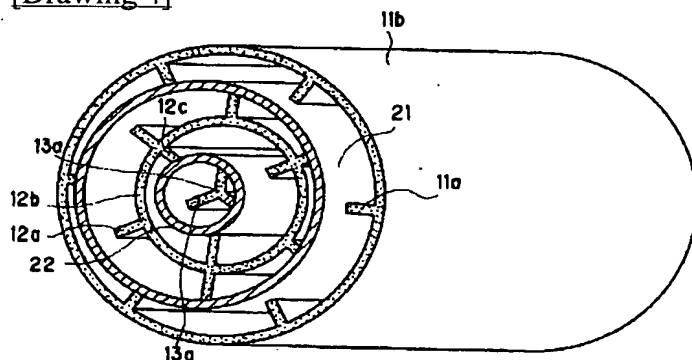
[Drawing 5]



[Drawing 7]

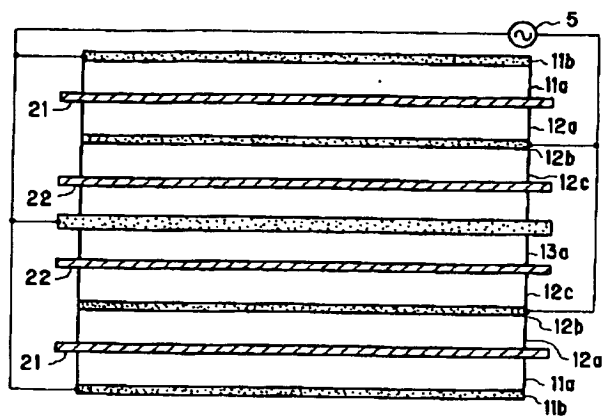


[Drawing 4]

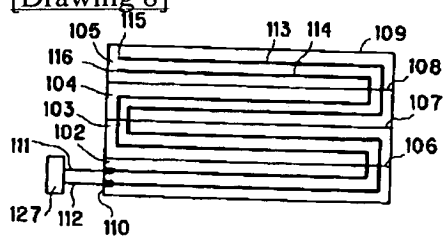


[Drawing 6]





[Drawing 8]



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